CHAPTER 2

DRAWINGS AND SPECIFICATIONS

The Naval bases, advance bases, Seabee camps, and equipment of the Navy were built from plans drawn on blueprints. They are operated, checked, and maintained according to information found on these same blueprints. When the equipment fails in service or is damaged in battle, blueprints are used to aid the repairman. When new parts are to be made or a facility is expanded, blueprints provide the necessary information Planning, scheduling, and manpower and material estimating are based on the information contained in these blueprints. This chapter discusses the function and care of blueprints and the importance of being able to read and work from them.

This chapter will also discuss electrical diagrams and schematics. Diagrams and schematics are maps that indicate the configuration of circuits and circuit connections and components of electrical equipment. When properly used, they are an invaluable aid in installation, troubleshooting, and repair of an electrical component. Understanding and being able to use blueprints and schematics will be some of the most important work assignments you will have as a Construction Electrician.

BLUEPRINTS

Blueprints are reproduced copies of mechanical or other types of technical drawings. The term *blueprint reading* means interpreting the ideas expressed by others on drawings whether the drawings are actually blueprints or not.

Drawing or sketching is the universal language used by engineers, technicians, and skilled craftsmen. Whether this drawing is made freehand or with drawing instruments, it is used to convey all the necessary information to the individual who will then fabricate and assemble the mechanical device.

PARTS OF A BLUEPRINT

Military blueprints are prepared as to size, format, location, and information included in the various blocks according to the Military Standards (ML-STD-100) (latest revision) Engineering Drawing Practices. American National Standard Institute (ANSI) is the mandatory publication used by the Navy for the graphic symbols (ANSI Y32.2—1975) and electrical wiring symbols (ANSI Y32.91—1972). These standards are used on electrical diagrams and electrical drawings. The various parts of a blueprint are described briefly in the following paragraphs.

Title Block

The requirements that determine what information must be included in a title block (fig. 2-1) vary. The title block, however, will contain the title of the drawing, the signature of the approving authority, the drawing number, the sheet number (when the drawing is one of a set of several sheets), and the number of sheets in the project set.

The Naval Facility Engineering Command (NAVFACENGCOM) also requires the following information in title blocks: the name and location of the activity; the specifications and contract numbers (if any); the preparing activity, including the architect-engineer (A-E) firm, if applicable; and the surnames of the personnel concerned in the preparation of the drawings. The code identification number 80091 is to appear in the title block of all NAVFACENGCOM drawings as well as a sheet designation letter (I—Index, C—Civil, A—Architectural, S—Structural, M—Mechanical, P—Plumbing, E—Electrical, and W—Waterfront).

Drawing Number

All blueprints are identified by a drawing number that appears in a block in the lower right-hand comer of the title block. The drawing number is especially important, both for purposes of filing the blueprint and for locating the correct drawing when it is specified on another blueprint.

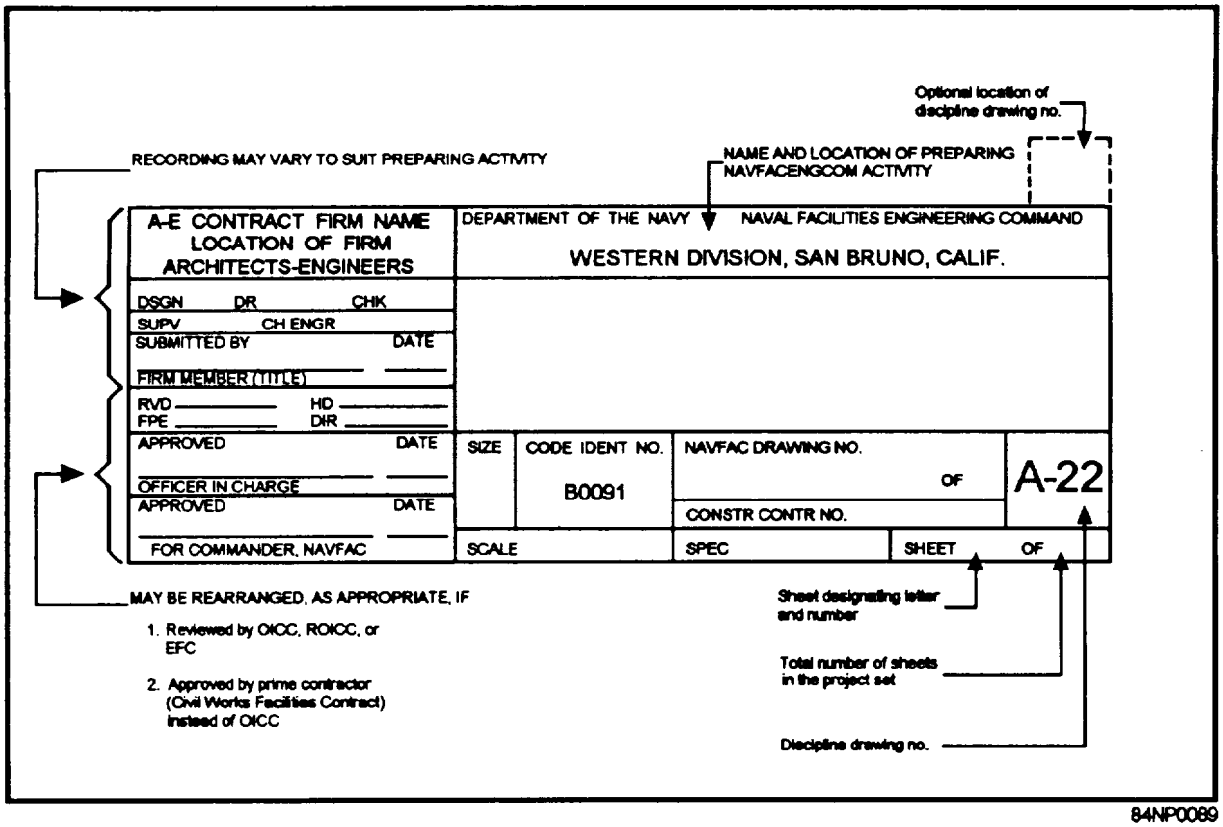


Figure 2-1.—Title block.

Revision Block

The revision block is usually located in the upper right-hand comer of the blueprint and is used for recording of changes (revisions) to the print. All revisions are noted in this block and are dated and identified by a letter and a brief description of the revision (fig. 2-2).

Scale

The graphic representation of the project is drawn to some proportion of the actual size of the project. One-eighth inch on such a drawing is equal to a foot of the actual size of the project. Although the original drawing is scaled accurately, your drawing will be a copy of that original and will not likely be the same size as the original drawing. The copy may have been reduced slightly. The paper size is also affected by temperature and humidity. The paper may stretch or shrink. Because of these factors, do not rely on measurements taken by laying a rule on the drawing. For example, do not assume that a number of units (as 1/8-inch increments) on the drawing is equal to that same number of feet on the project. This may or may

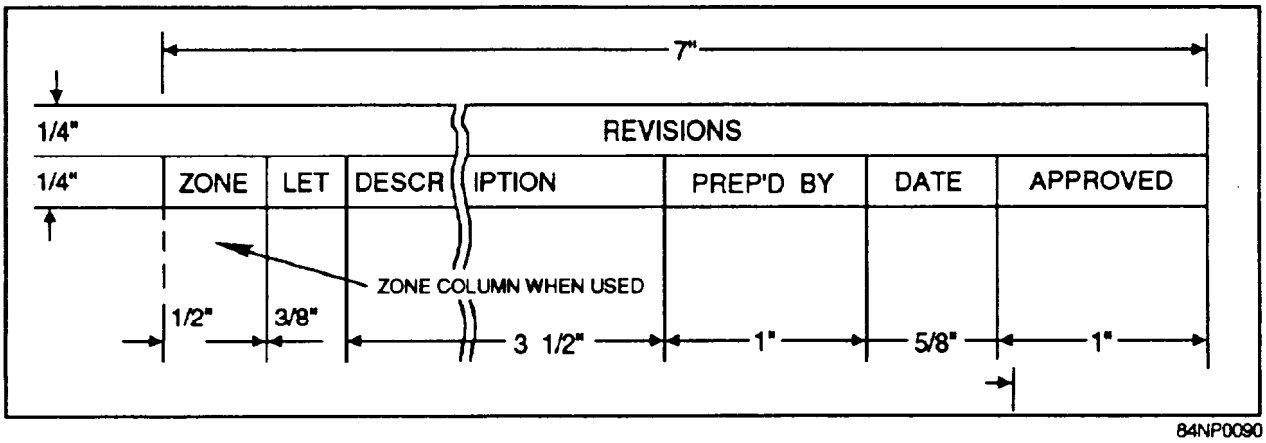


Figure 2-2.—Revision block.

not be true. The assumption can result in expensive and time-consuming rework. Play it safe and read the dimensions shown on the drawing.

Legend or Symbols

The legend, if used, is generally placed in the upper right-hand comer of a blueprint below the revision block. The legend is used to explain or define a symbol or special mark placed on a blueprint. A symbol may have more than one meaning. It should be noted that all symbols used are not from a single standard. The important thing is that you understand the meaning of the symbols on the drawing on which you are working. The legend will give you that meaning. The legend in figure 2-3 shows the symbols and their meanings from the partial floor plan below it.

Bill of Material

On a blueprint, the bill of material block contains a list of the parts and material used on or required by the print concerned. The block identifies parts and materials by stock number or other appropriate number and also lists the quantity used or required.

The bill of material often contains a list of standard parts, known as a parts list or schedule. Many commonly used items, such as machine bolts, screws, fittings, and valves, have been standardized by the

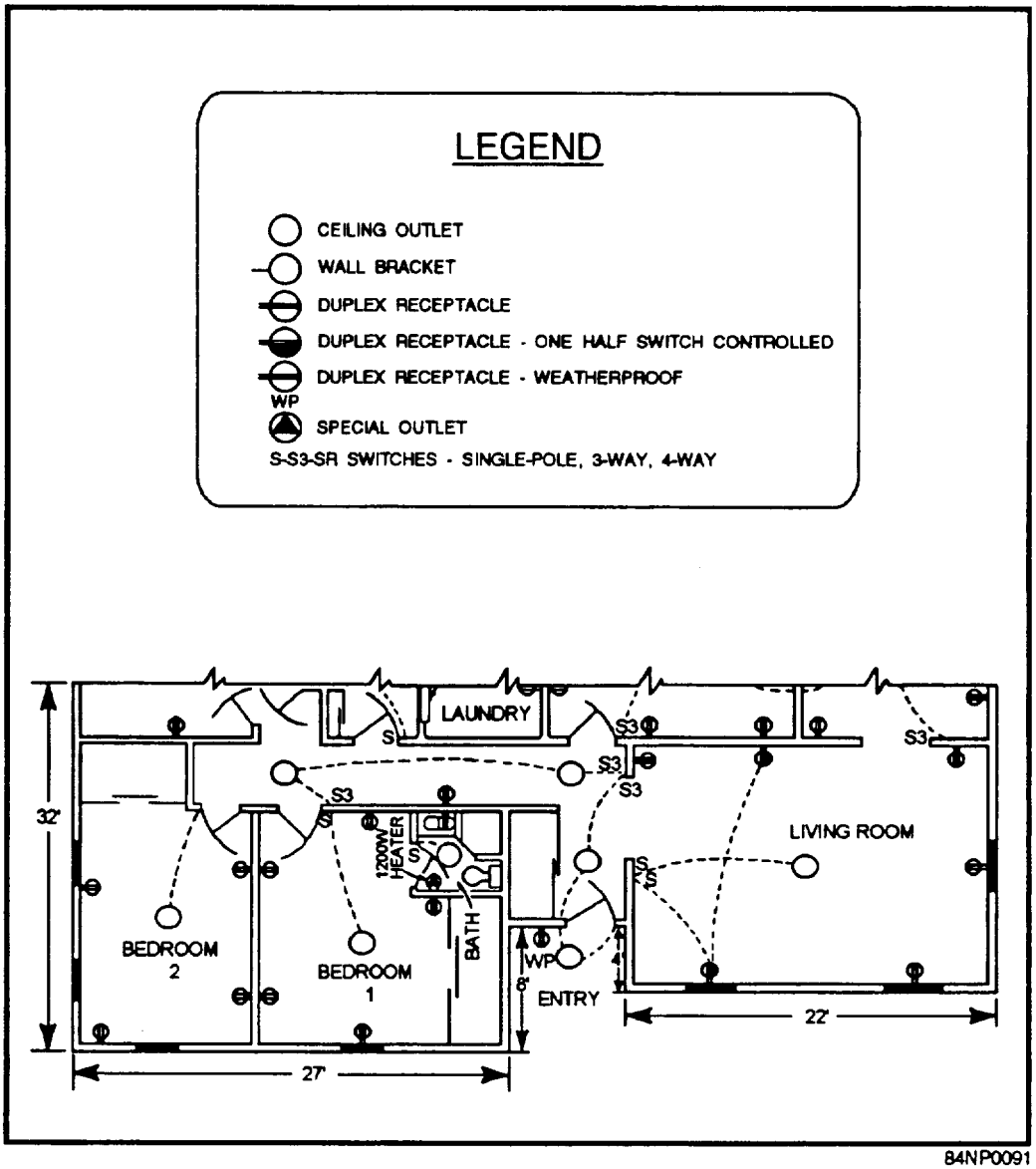


Figure 2-3.—A legend with partial floor plan.

military. A bill of material for an electrical plan is shown in figure 2-4.

SPECIFICATIONS

Even well-drawn construction drawings cannot adequately reveal all the aspects of a construction project. There are many features that cannot be shown graphically. For instance, how can anybody show on a drawing the quality of workmanship required for the installation of electrical equipment or who is responsible for supplying the materials, except by extensive hand-lettered notes. The standard procedure then is to supplement construction drawings with written descriptions. These detailed written instructions, commonly called specifications (specs), define and limit the materials and fabrication according to the intent of the engineer or the designer. The specifications are an important part of the project because they eliminate possible misinterpretation and ensure positive control of the construction.

There are many different types of specifications. A few of those common to the Naval Construction Force (NCF) will be discussed here.

NAVFACENGCOM SPECIFICATIONS

NAVFACENGCOM specifications are prepared by the Naval Facilities Engineering Command, which sets forth the standards of construction for the NCF and all work performed under the jurisdiction of the Naval Facilities Engineering Command.

Several types of specifications influence the preparation of NCF project specifications. These include NAVFACENGCOM guide specifications and type specifications; commercial specifications and standards; technical society and association standards, such as American National Standards Institute (ANSI) and Underwriters Laboratories (UL); and manufacturers' standards.

BILL OF MATERIALS

ITEM NO.	DESCRIPTION	UNIT	ASSEMBLY OR FSN NO.	QUANTITIES	
				TROP	NORTH
3-1	LIGHTING CIRCUIT - NAVFAC DWG. NO. 203414	EA	3016	3	3
3-2	POWER BUS, 100A - NAVFAC DWG. NO. 304131	EA	3047	1	1
3-3	RECEPTACLE CKT - NAVFAC DWG. NO. 303660	EA	3019	2	2
3-4	BOX, RECEPTACLE W/CLAMP FOR NONMETALLIC SHEATH WIRE	EA	5325-102-604	3	3
3-5	LAMP ELECTRIC, MED. BASE, INSIDE FROSTED, 200W, 120V	EA	6240-180-314	60	60
3-6	PLUG: ATTACHMENT, 3 WIRE, 15 AMP, 125 V	EA	5935-102-309	10	10
3-7	PLATE: BRASS, DUPLEX RECEPTACLE	EA	3325-800-101	5	5
3-8	RECEPTACLE, DUPLEX, 3 WIRE, 15 AMP, 125 V	EA	5325-100-102	5	5
3-9	ROD, GROUND, 3/4" X 10'-0"	EA	5306-200-180	12	12
3-10	WIRE, NO. 2 1/C STRANDED, HARD DRAWN, BARE	LB	6143-134-200	52	52
3-11	SWITCH, SAFETY, 2 P, ST 30 AMP, 250 V, PLUS FUSE	EA	5930-142-401	2	2
3-12	CLAMP, GROUND ROD	EA	5209-100-101	13	13
3-13	SWITCH, SAFETY, 200 AMP, 250 V, 3 P	EA	5930-201-903	1	1
3-14	FUSE, RENEWABLE, 200 AMP, 250 V	EA	5920-100-000	6	6
3-15	LINK, FUSE, 200 AMP, 250 V	EA	5920-100-001	6	6
	FUSE PLUG, 30 AMP, 125 V	EA	5920-100-102	12	12

ZZ84M004

Figure 2-4.—Bill of material.

FEDERAL AND MILITARY SPECIFICATIONS

Federal specifications cover the characteristics of materials and supplies used jointly by the Navy and other government agencies. Federal specifications do not cover installation or workmanship for a particular project but specify the technical requirements and tests for materials, products, and services. Federal specifications dictate the minimum requirements acceptable for use of all federal agencies. The engineering technical library should contain all of the commonly used federal specifications pertinent to Seabee construction.

Military specifications are those specifications that have been developed by the Department of Defense. Like federal specifications, they also cover the characteristics of materials. They are identified by MIL preceding the first letter and serial number, such as MIL-L-19140C (lumber and plywood, fire-retardant treated).

Your main concern will be with project specifications. Even if you do not see them, you should know that they exist and what kind of information they include.

PROJECT SPECIFICATIONS

Construction drawings are supplemented by written project specifications. Project specifications give detailed information regarding materials and methods of work for a particular construction project. They cover various factors relating to the project, such as general conditions, scope of work, quality of materials, standards of workmanship, and protection of finished work. The drawings, together with the project specifications, define the project in detail and show exactly how it is to be constructed. Usually, any set of drawings for an important project is accompanied by a set of project specifications. The drawings and project specifications are inseparable. The drawings indicate what the project specifications do not cover; and the project specifications indicate what the drawings do not portray, or they clarify further details that are not covered or amplified by the drawings and notes on the drawings. Whenever there is conflicting information on the drawings and project specifications, the project specifications take precedence over the drawings.

The general requirements are usually the first specifications listed for the structure, stating the type of foundation, character of load-bearing members (wood frame, steel frame, or concrete), type or types of doors and windows, types of mechanical and electrical installations, and the principal function of the building.

Next follows the specific conditions that must be carried out by the constructors. These are grouped in divisions under headings applying to each major phase of construction, such as the following typical list of divisions:

1. GENERAL REQUIREMENTS
2. SITE WORK
3. CONCRETE
4. MASONRY
5. METALS
6. CARPENTRY
7. MOISTURE CONTROL
8. DOORS, WINDOWS, AND GLASS
9. FINISHES
10. SPECIALTIES
11. EQUIPMENT
12. FURNISHINGS
13. SPECIAL CONSTRUCTION
14. CONVEYING SYSTEMS
15. MECHANICAL
16. ELECTRICAL
17. EXPEDITIONARY STRUCTURES

Sections under one of these general categories sometimes begin with general requirements for that category. For example: under DIVISION 16.—ELECTRICAL, the first section might read as follows:

> 16.—0l.—General Requirements.—Electrical installation must conform to the requirements of the National Electrical Code©. This includes all temporary work and the complete installation. The service entrance equipment must conform to the requirements of the local electric utility company if it is the source of electric power for the building or facility.

Subsequent sections under DIVISION 16.—ELECTRICAL would specify various quality criteria and standards of workmanship for the different types of electrical installation work; for example:

16.—05.—Installation of Wires and Cables. Installation of wire in conduit is made with the use of pull lines or fish tapes and an approved wire-pulling lubricant. Suitable equipment should be provided to prevent cutting or abrasion of conductor insulation during the pulling of the wires. Lubricating compound must not have a harmful effect on the conductor insulating materials. All wires in a conduit are bundled and pulled at one time. Pulling lines are attached by direct connection to the conductors or by the use of a cable grip. Slack is provided at attachment of devices or splicing. In outlet boxes, for future installation of wiring devices, the ends of wires are insulated with tape or a suitable wire connector. All conductors of each circuit in a junction box containing multiple circuits must be permanently identified with suitable labels.

Nonmetallic-sheathed cable may be installed exposed on walls and ceilings in protected areas or concealed in hollow walls, under floors, or above ceilings. Provisions for outlets and switches are made by running the cable into outlet boxes. All splices are enclosed in outlet or junction boxes; this requirement applies to both exposed and concealed installation.

The moment your battalion or unit receives orders to undertake a major construction project, watch for the arrival of sets of drawings and specifications, which are usually provided well in advance of the deployment period. These drawings and specifications will also be the basis for the P&E and scheduling. Take a look at the specifications. After you advance in rate, especially if you are concerned with P&E, it will be your responsibility to study the applicable specifications thoroughly.

NAVFACENGCOM has prepared specifications that cover practically every subject on naval construction. These specifications are the standards followed by the NCF—above all other specifications that may be available.

DRAWINGS AND SKETCHES

As a Construction Electrician you will be required to read and interpret drawings and specifications, sketches, and electrical diagrams. Before you can work with drawings effectively, you must know how to interpret electrical symbols correctly. Knowing how to draw and interpret freehand sketches is also important. You will see how the different parts of a drawing relate to the overall plan the drawing represents. You will also learn to recognize the different types of drawings and their uses.

SYMBOLS

One of the most important symbols to use right at the beginning of a new job is the directional symbol. This symbol, which is usually an arrow labeled "N" for north, enables the reader of a construction drawing to orient it. A drawing is properly oriented when it is held so that the north arrow shown on the drawing is pointing toward north. Construction Electricians sometimes find themselves standing in open ground with only a drawing and an area staked off by the Engineering Aid who tells them where to start shoveling for an underground conduit run. The drawing must be properly oriented so the reader can relate the information on it to the surrounding area. Understanding common standard symbols, such as the north arrow mentioned above, is a must for some one who expects to do well inelectrical construction work.

Some of the most common symbols you will see in building construction work are listed in figure 2-5. These symbols were selected from ANSI Y32.9—1972. Study these symbols carefully. A good way to memorize them is to copy each symbol several times while thinking of the electrical component or device it represents. Learn to relate each symbol mentally to the component it represents whenever you see the component. For example, as you pull the wire through a conduit in a floor slab, you might try to recall the symbol mentally for "wiring concealed in floor." When you walk into the company office and see a duplex receptacle outlet, you should think about its symbol. This practice will enable you to associate symbols to actual electrical devices. This type of training will help you become a better CE.

Although figure 2-5 shows some of the most common standard symbols, these are by no means the only ones you will see in your work. Sometimes a symbol for a particular component or device may have been created by the architect or engineer who developed the drawing. For various reasons, some of the symbols on a drawing may not be standard. Many times you will figure out what a symbol means by analyzing it and thinking about what it looks like. The legend on a drawing should show any nonstandard symbols and their meanings.

Lighting Outlets

Ceiling *Wall*

Surface or Pendant Incandescent, Mercury-Vapor, or Similar Lamp Fixture

Surface or Pendant Individual Fluorescent Fixture

Surface or Pendant Continuous-Row Fluorescent Fixture

Bare-Lamp Fluorescent Strip

Surface or Pendant Exit Light

Junction Box

Receptacle Outlets

Grounded *Ungrounded*

Single Receptacle Outlet

Duplex Receptacle Outlet

Duplex Receptacle Outlet–Split Wired

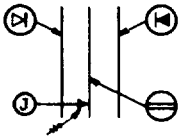
Single Special-Purpose Receptacle Outlet

Range Outlet (typical)

Floor Duplex Receptacle Outlet

Floor Telephone Outlet

Application: example of the use of various symbols to identify location of different types of outlets or connections for underfloor duct or cellular floor systems



Switch Outlets

Single-Pole Switch

S

Double-Pole Switch

S_2

Three-Way Switch

S_3

Four-Way Switch

S_4

Key-Operated Switch

S_K

Switch and Pilot Lamp

S_P

Switch for Low-Voltage Switching System

S_L

Switch and Single Receptacle

S

Switch and Double Receptacle

S

Door Switch

S_D

Time Switch

S_T

Residential Occupancies

Signaling system symbols for use in identifying standardized residential type signal system items on residential drawings where a descriptive symbol list is not included on the drawing.

Push button

Buzzer

Bell

Annunciator

Interconnection Box

Bell-Ringing Transformer

BT

Interconnecting Telephone

Radio Outlet

R

Television Outlet

TV

Panelboards, Switchboards, and Related Equipment

Flush-Mounted Panelboard and Cabinet

NOTE: Identify by notation or schedule.

Surface-Mounted Panelboard and Cabinet

Switchboard, Power Control Center, Unit Substations (should be drawn to scale)

Flush-Mounted Terminal Cabinet

NOTE: In small-scale drawings the TC may be indicated alongside the symbol.

TC

Surface-Mounted Terminal Cabinet

TC

Motor or Other Power Controller

MC

Externally Operated Disconnection Switch

Combination Controller and Disconnection Means

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Figure 2-5.—Graphic symbols used in building construction.

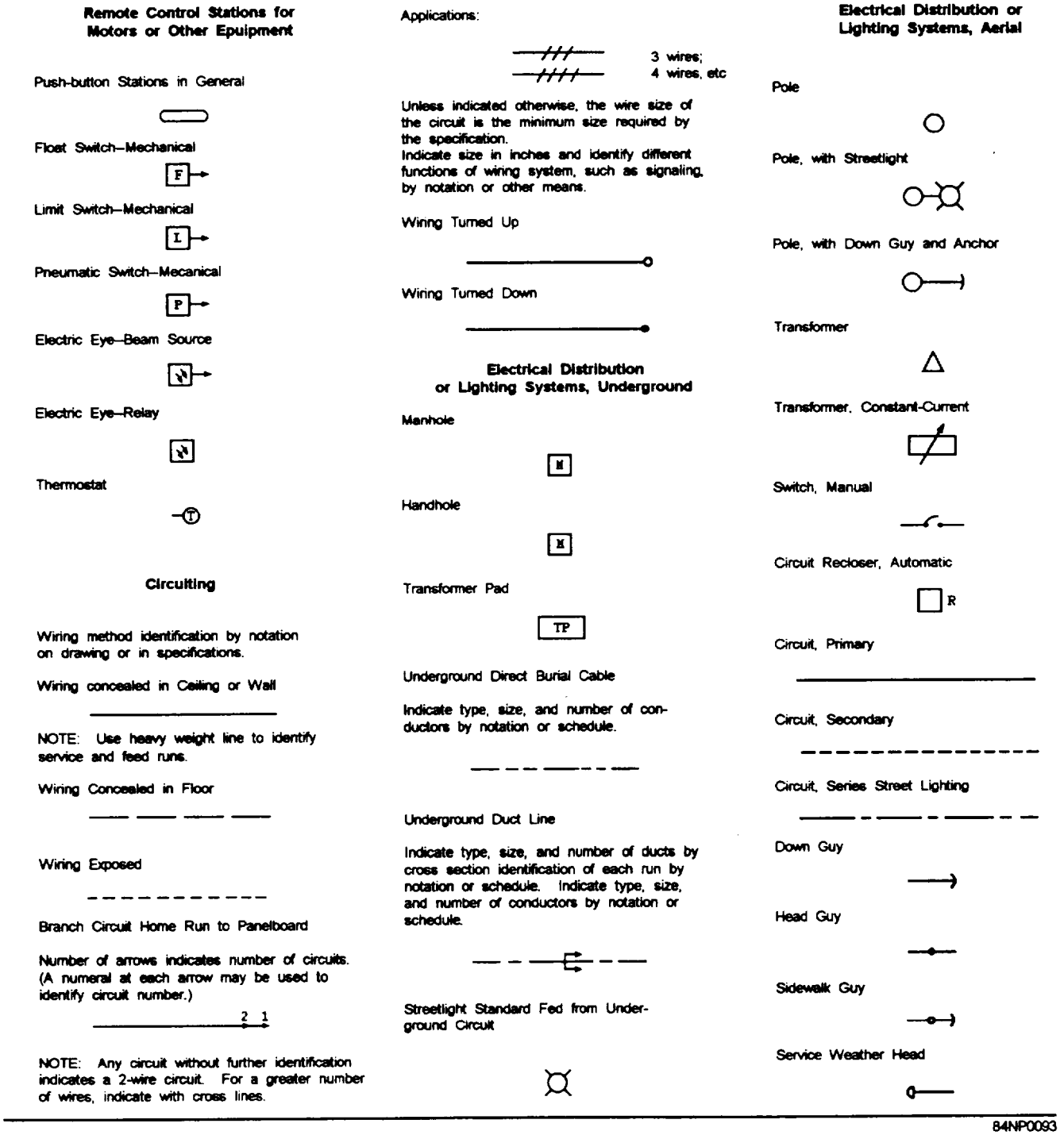


Figure 2-5.—Graphic symbols used in building construction—Continued.

Figure 2-6 shows some more standard electrical symbols. They may also be used in construction drawings but will most often be seen in other types of drawings, such as schematic diagrams. The symbols in figure 2-6 were selected from ANSI Y32.2-1975. This standard gives the following information about the symbols that may help you understand them better:

- Graphic symbols are used to show the functioning or interconnections of a circuit graphically.

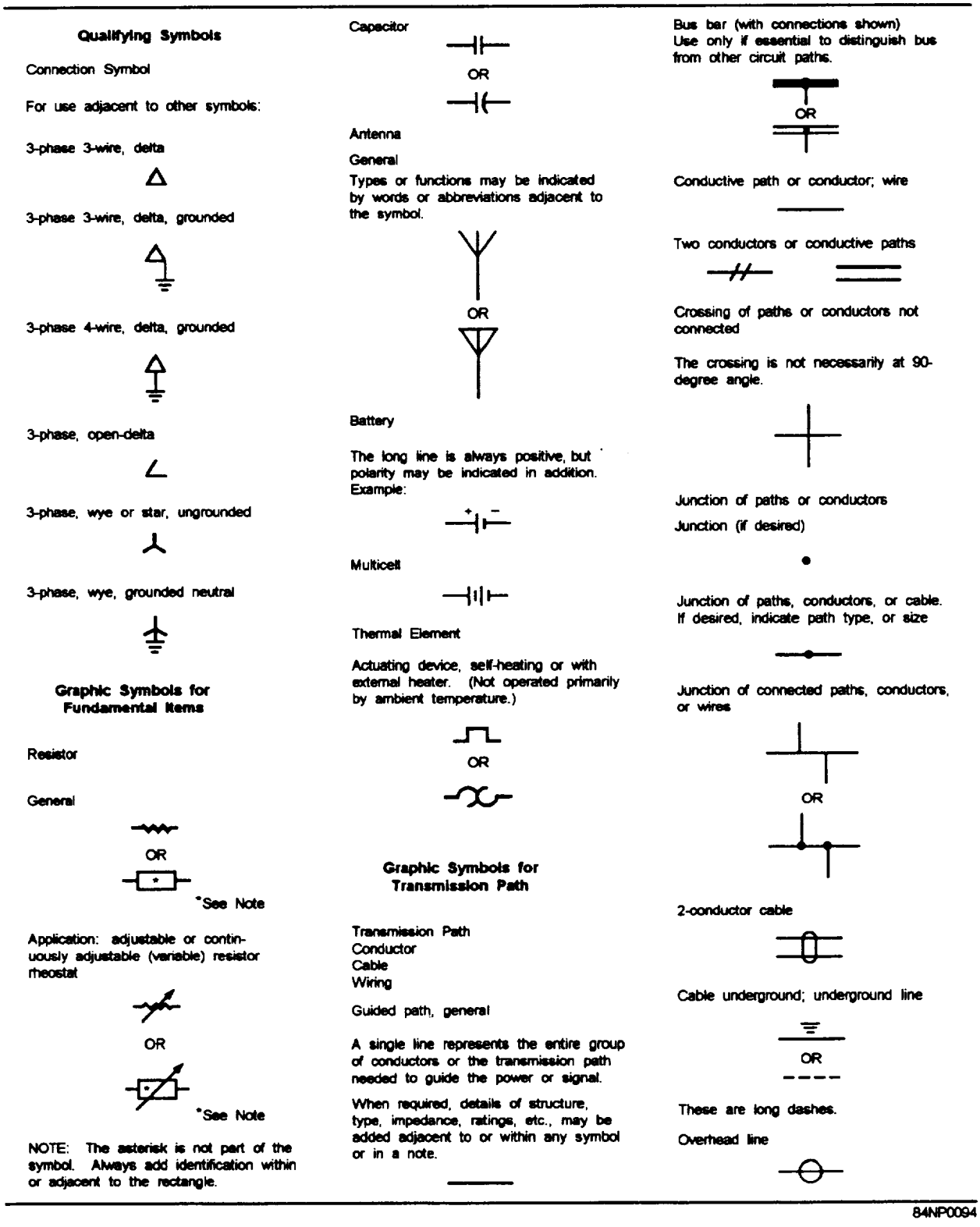


Figure 2-6.—Graphic symbols used in electrical and electronic diagrams.

Circuit Return

Ground general symbol

NOTE: Supplementary information may be added to define the status or purpose of the earth if this is not readily apparent.

(1) A direct conducting connection to the earth or body of water that is a part thereof.
(2) A conducting connect to a structure that serves a function similar to that of an earth ground (that is, a structure such as a frame of an air, space, or land vehicle that is not conductively connected to earth).

Chassis or frame connection; equivalent chassis connection (of printed-wiring boards)

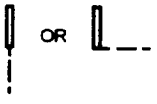
A conducting connection to a chassis or frame, or equivalent chassis connection of a printed-wiring board. The chassis or frame (or equivalent chassis connection of a printed-wiring board) may be at substantial potential with respect to the earth or structure in which this chassis or frame (or printed-wiring board) is mounted.

Graphic Symbols for Contacts, Switches, Contacts, and Relays

Electrical Contact

Fixed contact for jack, key, relay, switch, etc

‡ Sleeve



‡ The broken line - — - indicates where line connection to a symbol is made and is not part of the symbol

Moving Contact

Adjustable or sliding contact for resistor, inductor, etc

Locking

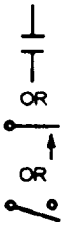
Nonlocking

Basic Contact Assemblies

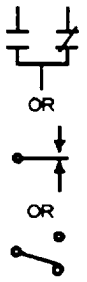
The standard method of shown a contact is by a symbol indicating the circuit condition it produces when the actuating device is in the de-energized or nonoperated position. The actuating device may be of a mechanical, electrical, or other nature, and a clarifying note may be necessary with the symbol to explain the proper point at which the contact functions; for example, the point where a contact closes or opens as a function of changing pressure, level, flow, voltage, current, etc. In cases where it is desirable to show contacts in the energized or operated condition and where confusion may result, a clarifying note shall be added to the drawing.

Closed contact (break)

Open contact (make)

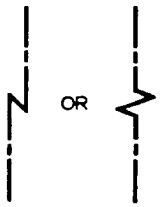


Transfer



Make-before-break

Magnetic Blowout Coil



Operating Coil
Relay Coil

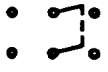
Switch

Fundamental symbols for contacts, mechanical connections, etc, may be used for switch symbols.

Single-throw, general

Double-throw, general

2-pole double-throw switch with terminals shown



NOTE: The asterisk is not part of the symbol. Always replace the asterisk by a device designation.

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Figure 2-6.—Graphic symbols used in electrical and electronic diagrams—Continued.

Push button, Momentary or Spring-Return

Circuit closing (make)

Circuit opening (break)

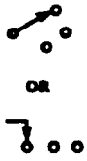
Two-circuit

Selector or Multiposition Switch

The position in which the switch is shown may be indicated by a note or designation of switch postion.

General (for power and control diagrams)

Any number of transmission paths may be shown.



Limit Switch
Sensitive Switch

NOTE: Identify by LS or other suitable note.

Track-type, circuit-closing contact

Track-type, circuit-opening contact

Flow-Actuated Switch

Closes on increase in flow

Opens on increase in flow

Liquid-Level-Actuated Switch

Closes on rising level

Opens on rising level

Pressure-or Vacuum-Actuated Switch

Closes on rising pressure

Opens on rising pressure

Temperature-Actuated Switch

Closes on rising temperature

Opens on rising temperature

Thermostat

Closes on rising temperature

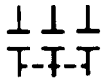
*See Note

Contactor

See also CIRCUIT BREAKER

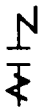
Fundamental symbols for contacts, coils, mechanical connections, etc, are the basis of contactor symbols and should be used to represent contactors on complete diagrams. Complete diagrams of contactors consist of combinations of fundamental symbols for control coils, mechanical connections, etc, in such configurations as to represent the actual device. Mechanical interlocking should be indicated by notes.

Manually operated 3-pole contactor



NOTE: The t° symbol shall be shown or be replaced by data giving the nominal or specific operating temperature of the device.

Electrically operated 1-pole contactor with series blowout coil



Electrically operated 3-pole contactor with series blowout coils; 2 open and 1 closed auxiliary contacts (shown smaller than the main contacts)

Relay

Fundamental symbols for contacts, mechanical connections, coils, etc, are the basis or relay symbols and should be used to represent relays on complete diagrams.

The following letter combinations or symbol elements may be used with relay symbols. The requisite number of these letters or symbol elements may be used to show what special features a relay possesses.

AC Alternating-current or ringing relay
D Differential
DB Double-biased (biased in both directions)
DP Dashpot
EP Electrically polarized
FO Fast-operate
FR Fast-release
L Latching
MG Marginal
ML Magnetic-latching (remanent
NB No bias
NR Nonreactive

P Magnetically polarized using biasing spring, or having magnet bias
SA Slow-operate and slow-release

SO Slow-operate
SR Slow-release
SW Sandwich-wound to improve blance to longitudinal currents

The proper poling for a polarized relay shall be shown by the use of + and – designations applied to the winding leads. The interpretation of this shall be that a voltage applied with the polarity as indicated shall cause the armature to move toward the contact shown nearer the coil on the diagram. If the relay is equipped with numbered terminals, the proper terminal numbers shall also be shown.

Basic

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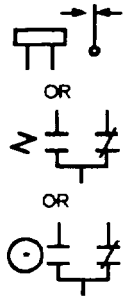
Figure 2-6.—Graphic symbols used in electrical and electronic diagrams—Continued.

Relay with transfer contacts



Graphic Symbols for Terminals and Connectors

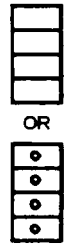
Terminals

Circuit terminal

Terminal board or terminal strip, with 4 terminals shown; group of 4 terminals

Number and arrangement as convenient.

NOTE: Internal lines and terminals may be omitted if terminal identifications are shown within the symbol.



Cable Termination

Line shown on left of symbol indicates cable.

Connector
Disconnecting Device
Jack
Plug

The contact symbol is not an arrowhead. It is larger and the lines are drawn at a 90-degree angle.

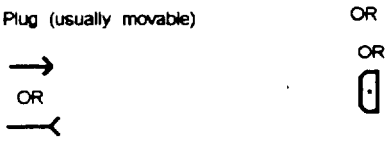
Female contact 

Male contact 

Receptacle or jack (usually stationary)

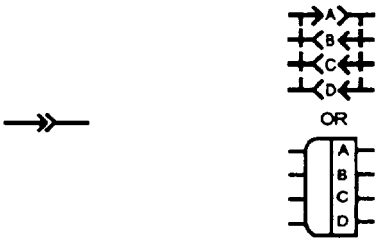
NOTE: The asterisk is not part of the symbol. If desired, indicate the type of contacts: male (—►) or female (►—).

Plug (usually movable)



Separable connectors (engaged)

Engaged 4-conductor connectors; the plug has 1 male and 3 female contacts with individual contact designations shown in the complete-symbol column



Communication switchboard-type connector

2-conductor (jack) 

2-conductor (plug) 

Graphic Symbols for Transformers, Inductors, and Windings

Core

General or air core

If it is necessary to identify an air core, a note should appear adjacent to the symbol of the inductor or transformer

NO SYMBOL

Magnetic core of inductor or transformer

Not to be used unless it is necessary to identify a magnetic core.

Inductor
Winding (machine or transformer)
Reactor
Radio-Frequency Coil
Telephone Retardation Coil

See also OPERATING COIL

General

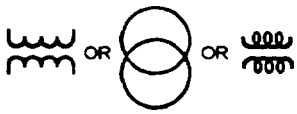
Magnetic-core inductor
Telephone loading coil

If necessary to show a magnetic core.

Tapped

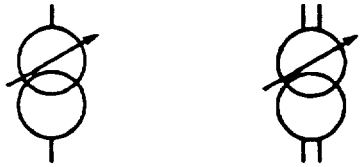
Adjustable inductor

Transformer
General



Shielded transformer with magnetic core shown

One winding with adjustable inductance



Adjustable mutual inductor; constant-current transformer

Autotransformer, 1-phase

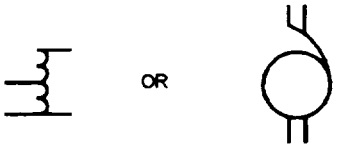


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Figure 2-6.—Graphic symbols used in electrical and electronic diagrams—Continued.

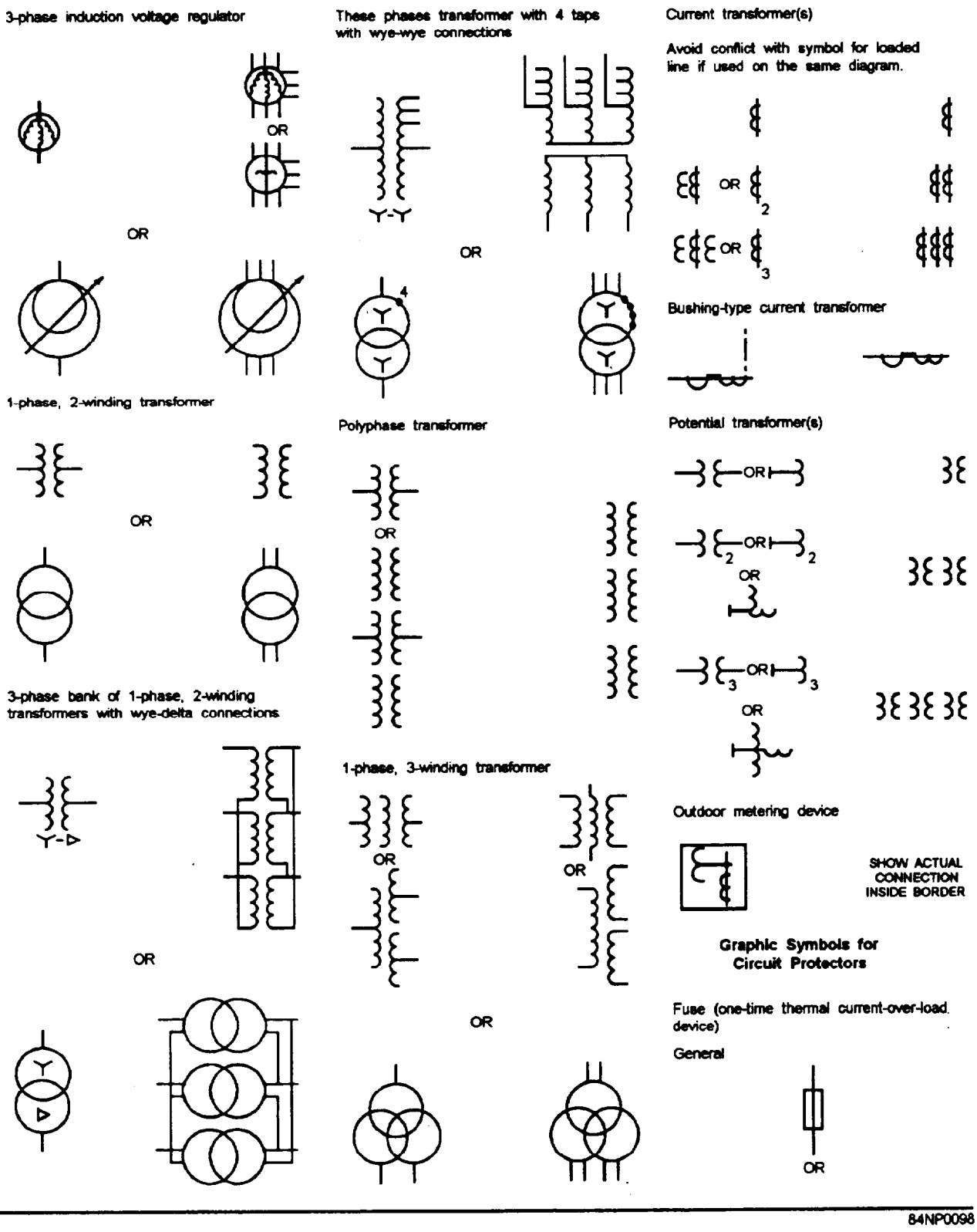


Figure 2-6.—Graphic symbols used in electrical and electronic diagrams—Continued

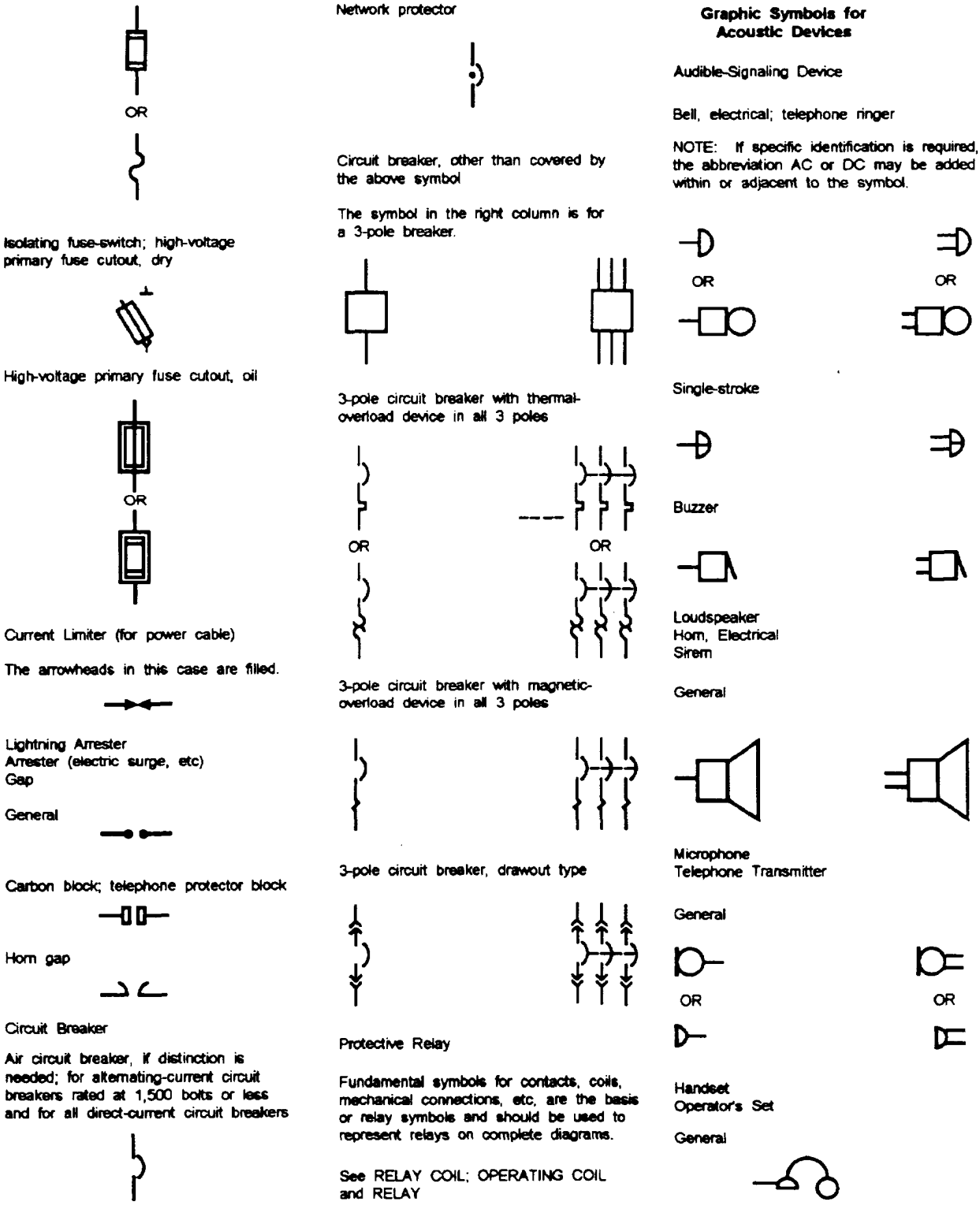


Figure 2-6.—Graphic symbols used in electrical and electronic diagrams—Continued.

Telephone Receiver
Earphone

General

Headset, double

Headset, single

Graphic Symbols for Lamps and Visual-Signaling Devices

Lamp

Lamp, general; light source, general

NOTE: This symbol may be used to represent one or more lamps with or without operating auxiliaries.

NOTE: If it is essential to indicate the following characteristics, the specified letter or letters may be inserted within or placed adjacent to the symbol.

A	Amber
B	Blue
C	Clear
G	Green
O	Orange
OP	Opalescent
P	Purple
R	Red
W	White
Y	Yellow
ARC	Arc
EL	Electroluminescent
FL	Fluorescent
HG	Mercury vapor
IN	Incandescent
IR	Infrared
NA	Solium vapor
NE	Neon
UV	Ultraviolet
XE	Xenon
LED	Light-emitting diode

Fluorescent lamp

2-terminal

4-terminal

Incandescent lamp (incandescent-filament illuminating lamp

Ballast lamp; ballast tube

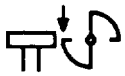
The primary characteristic of the element within the circle is designed to vary non-linearly with the temperature of the element.

Visual-Signaling Device

Annunciator (general)

Annunciator drop or signal, shutter or grid type

Annunciator drop or signal, ball type



Manually restored drop

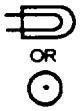
Electrically restored drop

Communication switchgoard-type lamp; indicating lamp

Indicating, pilot, signaling, or switch-board light; indicator light signal light

If confusion with other circular symbols may occur, the D-shaped symbol should be used.

OR



Jeweled signal light

Graphic Symbols for Readout Devices

Meter Instrument

NOTE: The asterisk is not part of the symbol. Always replace the asterisk by one of the following letter combinations, depending on the function of the meter or instrument, unless some other identification is provided in the circle and explained on the diagram.

A	Ammeter
AH	Ampere-hour meter
C	Coulombmeter
CMA	Contact-making (or breaking) ammeter
CMC	Contact-making (or breaking) clock
CMV	Contact-making (or breaking) voltmeter
CRO	Oscilloscope Cathode-ray oscillograph
DB	DB (decibel) meter Audio level/meter
DBM	DBM (decibels referred to 1 milliwatt) meter
DM	Demand meter
DTR	Demand-totalizing relay
F	Frequency meter
GD	Ground detector
I	Indicating meter
μA or UA	Microammeter
MA	Milliammeter
NM	Noise meter
OHM	Ohmmeter
OP	Oil pressure meter
OSCG	Oscillograph, string
PF	Power factor meter
PH	Phasemeter
PI	Position indicator
RD	Recording demand meter
REC	Recording meter
RF	Reactive factor meter
SY	Synchroscope
t°	Temperature meter
THC	Thermal converter
TLM	Telemter
TT	Total time meter Elapsed time meter
V	Voltmeter
VA	Volt-ammeter
VAR	Varmeter
VARH	Varhour meter
VI	Volume indicator Audio-level meter
VU	Standard volume indicator Audio-level meter
W	Wattmeter
WH	Watthour meter

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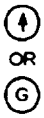
Figure 2-6.—Graphic symbols used in electrical and electronic diagrams—Continued.

Galvanometer



Graphic Symbols for Rotating Machinery

Rotating Machine

Basic

Generator (general)

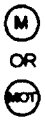
Avoid conflict with symbols for galvanometer if used on the same diagram.

OR

Generator, direct-current

Generator, alternating-current

Motor (general)



Motor, direct-current

Motor, alternating-current

Winding Connection Symbols

Motor and generator winding connection symbols may be shown in the basic circle using the following representations.

1-phase

2-phase

3-phase wye (ungrounded)

3-phase wye (grounded)

3-phase delta

Alternating-Current Machines

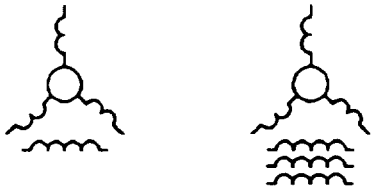
Squirrel-cage induction motor or generator, split-phase induction motor or generator, rotary phase converter, or repulsion motor

Wound-rotor induction motor, synchronous induction motor, induction generator, or induction frequency converter

1-phase shaded-pole motor

1-phase repulsion-start induction motor

3-phase regulating machine



Alternating-Current Machines with Direct-Current Field Excitation

Synchronous motor, generator, or condenser

Graphic Symbols for Mechanical Functions

Mechanical Connection
Mechanical Interlock

Mechanical connection

The top symbol consists of short dashes.

NOTE: The short parallel lines should be used only where there is insufficient space for the short dashes in series.

Mechanical Motion

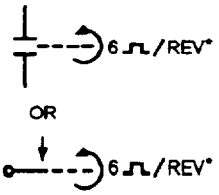
Translation, one direction

Translation, both directions

Rotation, one direction

Application: angular motion, applied to open contact (make), symbol

NOTE: The asterisk is not part of the symbol. Explanatory information (similar to type shown) may be added if necessary to explain circuit operation.



Rotation, both directions

Alternating or reciprocating

Rotation designation (applied to a resistor)

CW indicates position of adjustable contact at the limit of clockwise travel viewed from knob or actuator end unless otherwise indicated.

84NP0101

Figure 2-6.—Graphic symbols used in electrical and electronic diagrams—Continued.

NOTE: The asterisk is not part of the symbol. Always add identification within or adjacent to the rectangle.

OR

Manual Control

General

Operated by pushing

Operated by pushing and pulling (push-pull)

Graphic Symbols for Composite Assemblies

Circuit Assembly
Circuit Subassembly
Circuit Element

NOTE: The asterisk is not part of the symbol. Always indicate the type of apparatus by appropriate words or letters

NOTE: The use of a general circuit-element symbol is restricted to the following:

a. Diagrams drawn in block form.
b. A substitute for complex circuit elements when the internal operation of the circuit element is not important of the purpose of the diagram.

General

Accepted abbreviations from ANSI Z32.13-1950 may be used in the rectangle.

The following letter combinations may be used in the rectangle:

CLK	Clock
EQ	Equalizer
FAX	Facsimile set
FL	Filter
IND	Indicator
PS	Power supply
RG	Recording unit
RU	Reproducing unit
DIAL	Telephone dial
TEL	Telephone station
TPR	Teleprinter
TTY	Teletypewriter

Amplifier

General

The triangle is pointed in the direction of transmission.

The symbol represents any method of amplification (electron tube, solid-state device, magnetic device, etc).

NOTE: If identification, electrical values, location data, and similar information must be noted within symbol, the size or aspect ratio the original symbol may be altered providing its distinctive shape is retained.

Amplifier use may be indicated in the triangle by words, standard abbreviations, or a letter combination from the following list:

BDG	Bridging
BST	Booster
CMP	Compression
EXP	Direct-current
LIM	Limiting
MON	Monitoring
PGM	Program
PRE	Preliminary
PWR	Power
TRQ	Torque

Application: amplifier with associated power supply

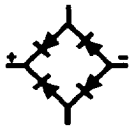
General

NOTE: Triangle points in direction of forward (easy) current as indicated by a direct-current ammeter, unless otherwise noted adjacent to the symbol. Electron flow is in the opposite direction.

NOTE: This symbol represents any method of rectification (electron tube, solid-state device, electrochemical device, etc).

Controlled

Bridge-type rectifier



On connection or wiring diagrams, rectifier may be shown with terminals and polarity marking. Heavy line may be used to indicate nameplate or positive-polarity end.

For connection or wiring diagram

84NP0102

Figure 2-6.—Graphic symbols used in electrical and electronic diagrams—Continued.

A graphic symbol represents the function of a part in the circuit.

- Qualifying symbols may be added to symbols when the special characteristic is important to the function of the device and aids in the understanding of the overall function performed. For example, connection symbols shown in column 1 of figure 2-6 are headed "Qualifying Symbols." They are combined with transformer symbols shown further on in the figure.

- Some symbols may be similar or identical to other symbols but have different meanings. Only one meaning will apply to a specific symbol used on a diagram. Notes, asterisks, and flagging techniques may be used with symbols having multiple meanings. A tabulation listing the intended meanings should be provided.

Except where noted, the orientation of a symbol on a drawing does not alter the meaning of the symbol.

FREEHAND SKETCHES

When installing electrical systems and circuits, you will sometimes have to exchange information about your job with others. A freehand sketch can be an accurate and a concise way to communicate this information.

This type of drawing is informal in character, may or may not be drawn to scale, and need not follow any particular format. A sketch can be used in many ways. One example of where to use a sketch is to show a field change that must be made. Nomatterhowwellaproject is planned, occasionally field changes have to be made. You may see that a field change is necessary because a conduit run cannot practically be routed according to the approved drawing or plan. You can make a freehand sketch showing only what has to be changed. The sketch may include dimensions, symbols, and other information needed to convey your idea of the required change to someone else (like the project supervisor or project chief).

TYPES OF DRAWINGS AND DIAGRAMS

The types of drawings to be discussed here include working drawings, architectural drawings, mechanical drawings, shop drawings, and electrical diagrams.

CONSTRUCTION DRAWINGS

A construction drawing is any drawing that furnishes the information required by the craftsmen to rough in equipment or erect a structure. The terms **working drawings** and **construction drawings** are sometimes used interchangeably. Information presented in a set of working drawings, along with the specifications, should be complete so the craftsman who uses them will require no further information.

Working drawings show the size, quantity, location, and relationship of the building parts. Generally, working drawings may be divided into three main categories: architectural, mechanical, and electrical.

- Regardless of the category, working drawings serve several functions:

- They provide a basis for making material, labor, and equipment estimates before construction starts.

- They give instructions for construction, showing the sixes and location of the various parts.

- They provide a means of coordination between the different ratings.

- They complement the specifications; one source of information is incomplete without the other when drawings are used for construction work.

Architectural Drawings

Architectural drawings consist of all the drawings that describe the structural members of the building and their relationship to each other. This includes foundation plans, floor plans, framing plans, elevations, sections, details, schedules, and bills of materials.

Plans

A plan is actually a part of the architectural drawing that represents a view of the project from above. Two types of plans will be discussed here: plot plans and floor plans.

PLOT PLANS.—A plot plan (also called a site plan) includes not only the project but also the surrounding area. The project may be represented only by an outline, such as the Director's Quarters project on the plot plan in figure 2-7. The grades at fixed points are shown throughout the area. This is done to show how the land slopes before construction is started and the finished grade after construction is completed. The north arrow symbol, used for orientation of the drawing, is shown. The Construction Electrician may have to have a plot plan to construct a pole line to the project site at or near the earliest phase of construction. Another example is when the slope and grade of the surrounding area is to be changed and you have to bury cable or conduit. You must know what the finished grade is and how deep to dig. This type of work requires close coordination between you, the Engineering Aids, Equipment Operators, and Builders. By looking over the plot plan, you will know what to do to prepare for the job.

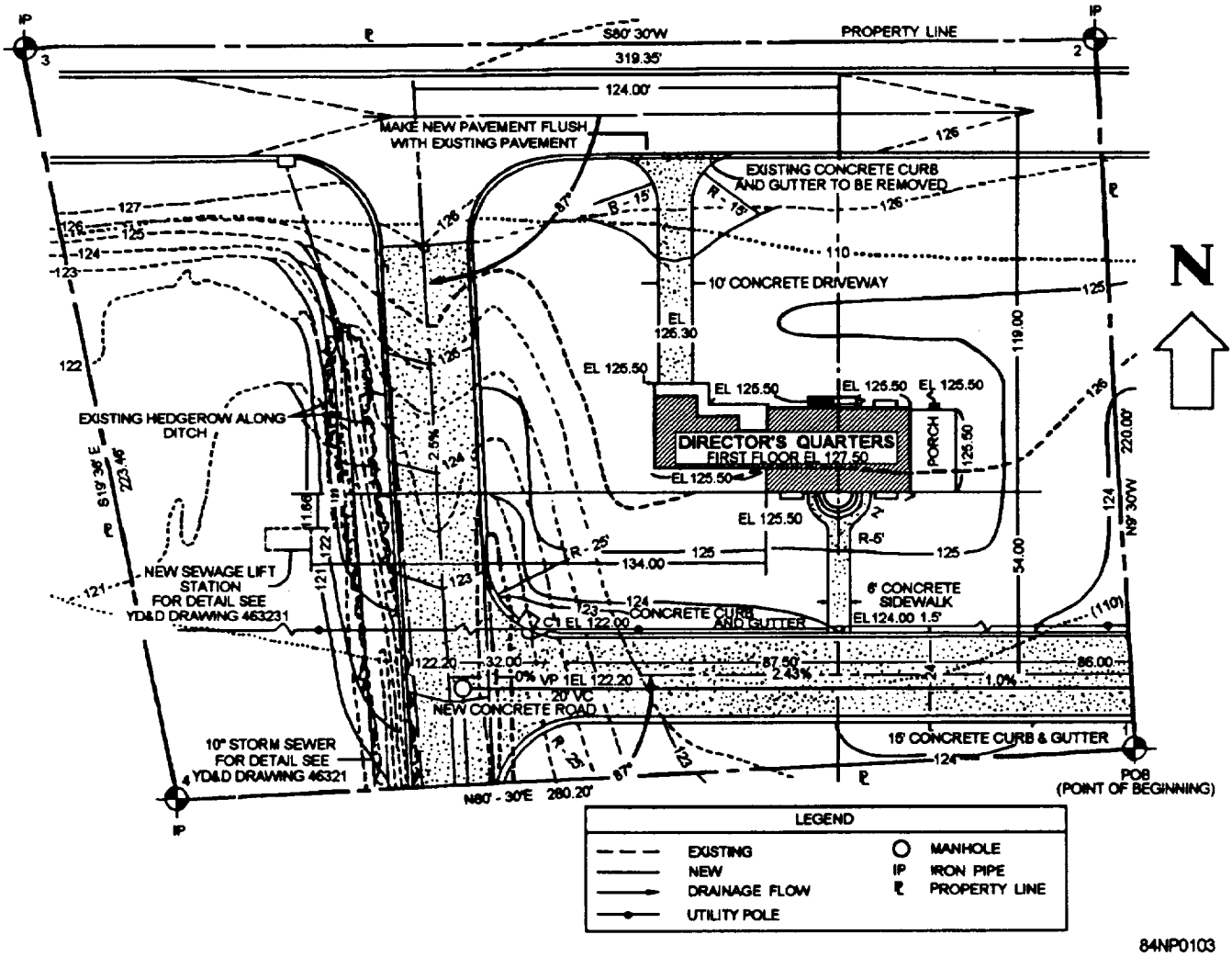


Figure 2-7.—Plot plan including "Director's Quarters" project.

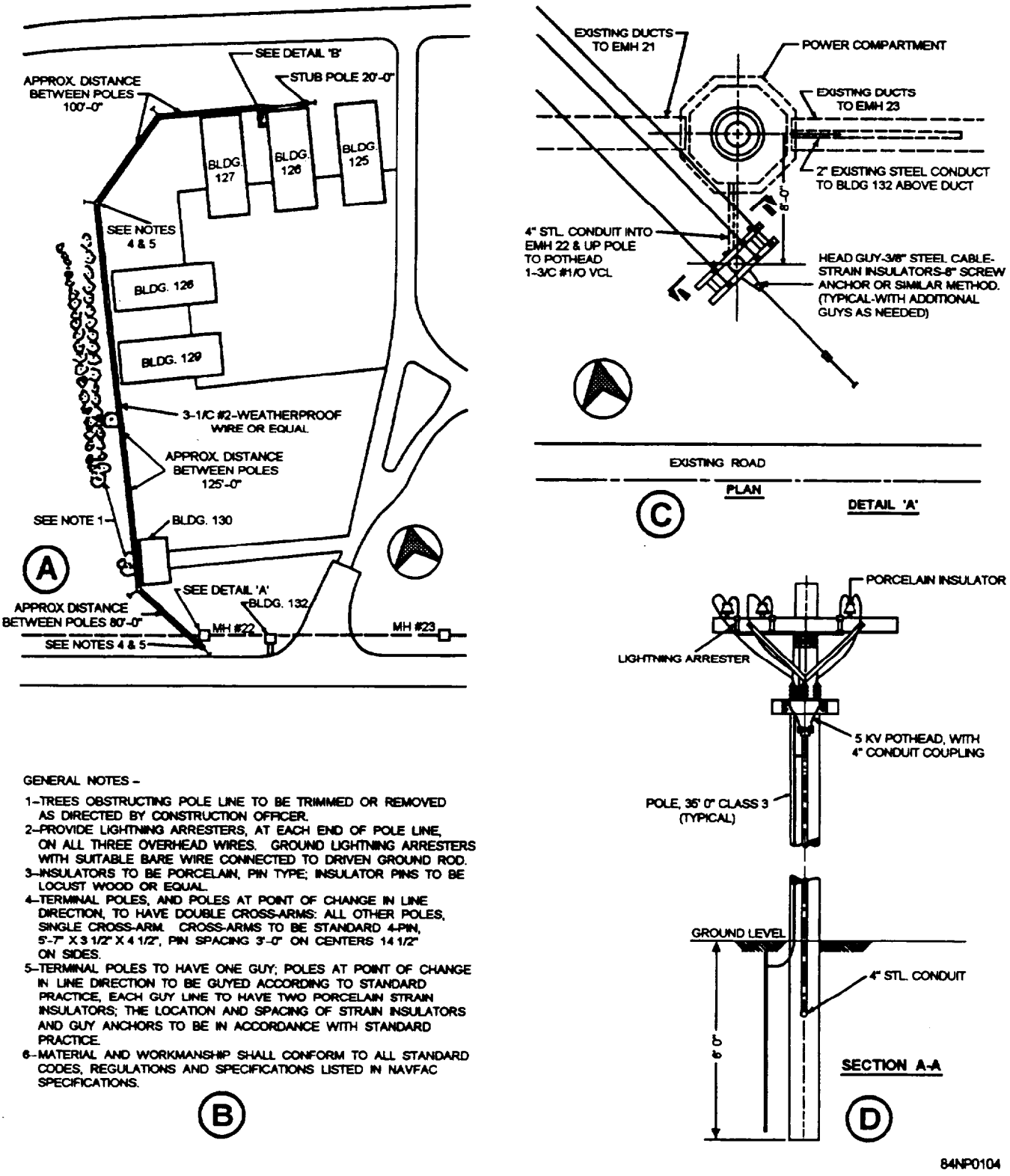


Figure 2-8.—Plot plan with electrical layout, general notes, detail, and section drawings.

Another type of plot plan can be seen in figure 2-8. Figure 2-8, view A, shows five buildings that are to be supplied with electricity for power and lighting. An electrical layout has been superimposed on the plot plan General notes (fig. 2-8, view B), one detail (fig. 2-8, view C), and section A-A (fig. 2-8, view D) of that detail are shown The dotted line at the bottom of the page indicates underground ducts containing previously laid cable.

The design engineer has decided to tap the cable at manhole 22 and run lines overhead to dead-end at the rear of building 126. Figure 2-8, view C, shows that lines are to be run underground from manhole 22 to the first pole crossarms. At building 126, lines are to be carried down the pole, regathered through a pothead into the conduit again, and run underground to a concrete slab, and out through another pothead to a transformer bank. Where do you get this information? Refer to figure 2-9.

Figure 2-9 shows detail B is indicated in figure 2-8, view A. This represents the installation behind building 126 where the overhead line terminates. The last pole in the system is shown in the lower left comer. From the pole to the transformer bank, the underground conduit is indicated by dotted lines. The conduit runs underground to the concrete slab on which the transformers rest. Section A-A gives construction details of the slab.

FLOOR PLANS.—Imagine that you want to know the outline of a building, including each partition.

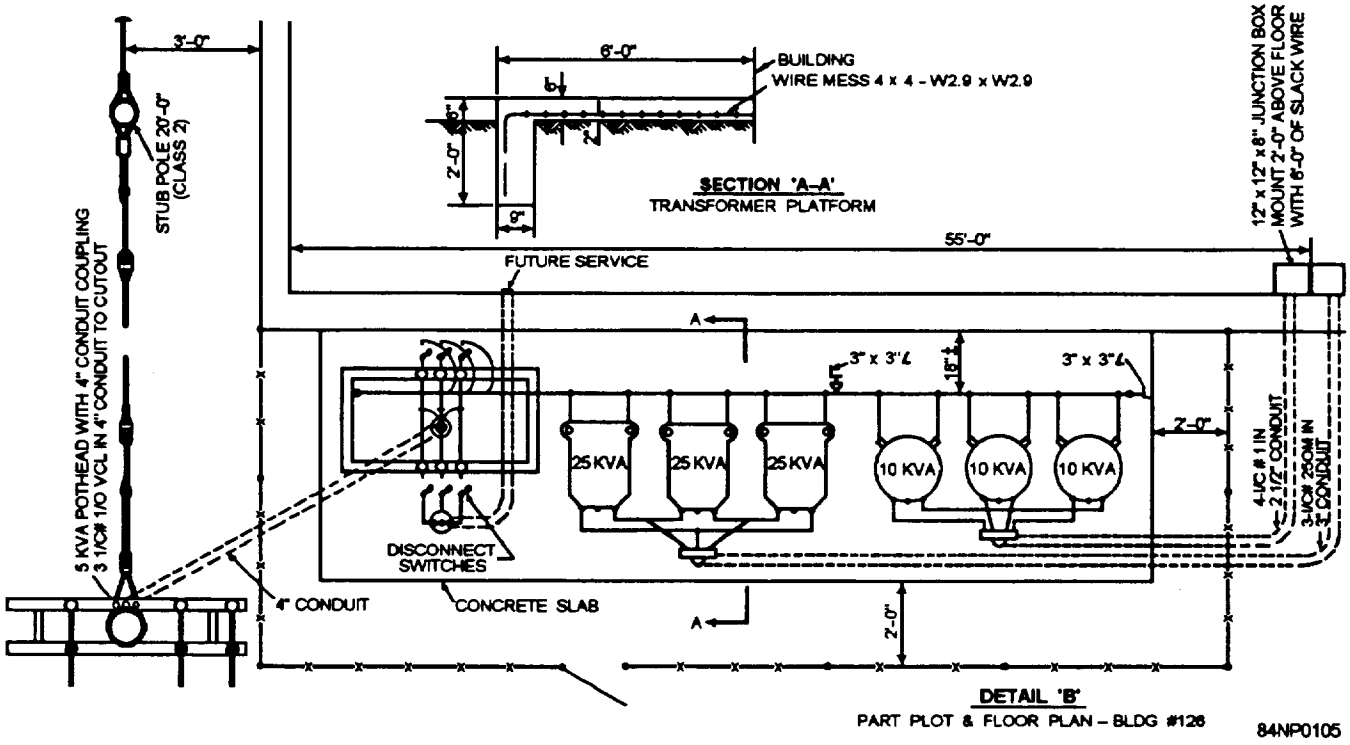


Figure 2-9.—Detail B indicated in figure 2-8.

This building is shown in figure 2-10, view A, and you areequippedwithahugesaw. Ifyousawedthe building in half horizontally and looked down on it from above, you would see the complete outline of the building (view B). This particular view directly above would be called a floor plan (view C). Architects and engineers project their thoughts of a building, not yet built, onto a piece of paper and call it a floor plan. It does not matter that the heights of the outlets, appliances, or building parts are different. These heights will be indicated by figures in inches or feet, next to the symbols that represent them. Electrical construction drawings are floor plans modified by the inclusion of electrical symbols.

Figure 2-11 shows an electrical layout superimposed on an outline taken from an architectural floor plan The service line that brings power into the house is a three-wire line in 1 1/4-inch conduit. The service line feeds power by way of a service switch to a lighting panel, from which three branch circuits run to the lighting fixtures and convenience outlets in the rooms. The symbols for these fixtures and outlets and the service switch are shown at the bottom of figure 2-11.

Elevations

An elevation is a drawing that represents a view of the finished structure as you would see it from the front, back, left, or right. There are interior elevations, such as a view of a fireplace, as well as exterior elevations, as shown in the elevations of a small building shown in figure 2-12.

Doors, windows, shapes of roof, chimneys, and exterior materials are shown. These views provide the viewer with a finished appearance.

Few dimensions are given on elevations. Only those vertical dimensions that cannot be shown on the plan are generally included on an elevation view. A Construction Electrician can quickly see from any one of the elevations in figure 2-12 that there is an attic where easy access would be provided to electrical wiring. This is important where there is a requirement for junction boxes that must be accessible. The electrician can also see a foundation wall where, if a service lateral is required, a conduit or sleeve must be placed (for a later run of conduit). This knowledge will allow the electrician to plan ahead to work with the

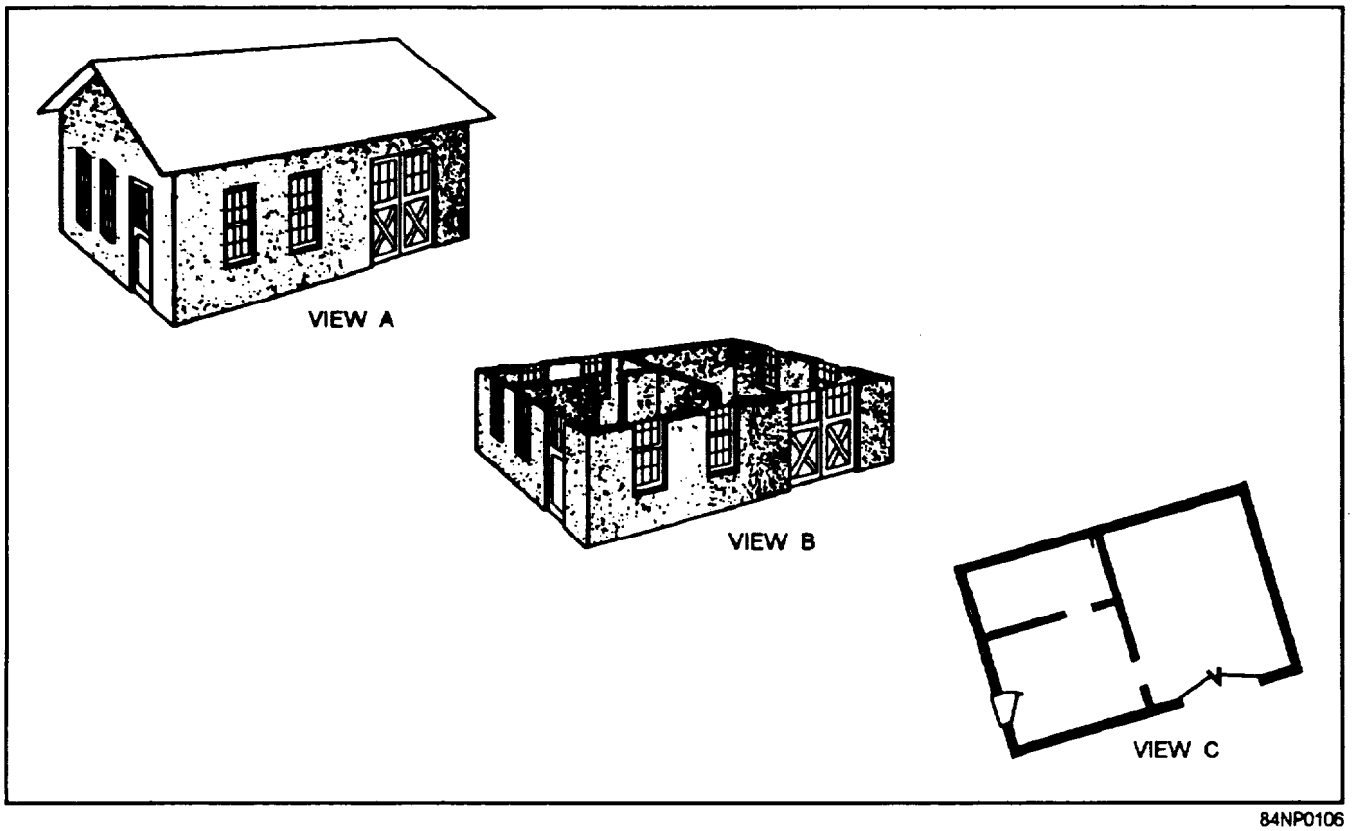


Figure 2-10.—Floor plan development.

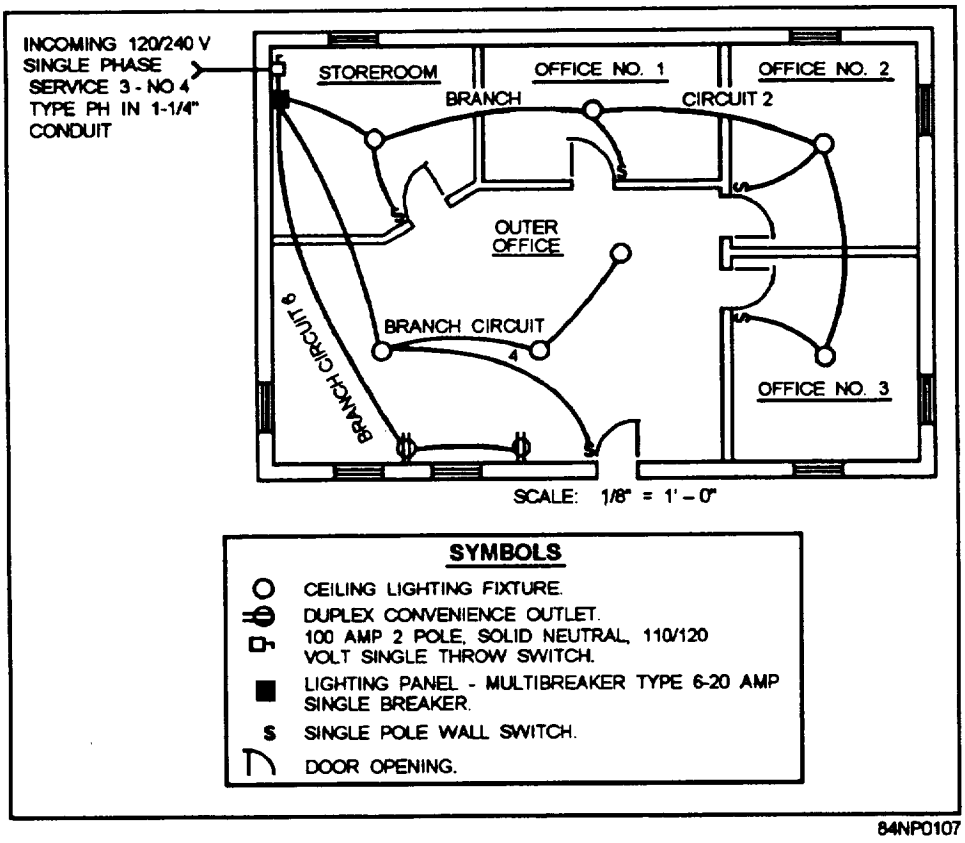


Figure 2-11.—Electrical floor plan layout.

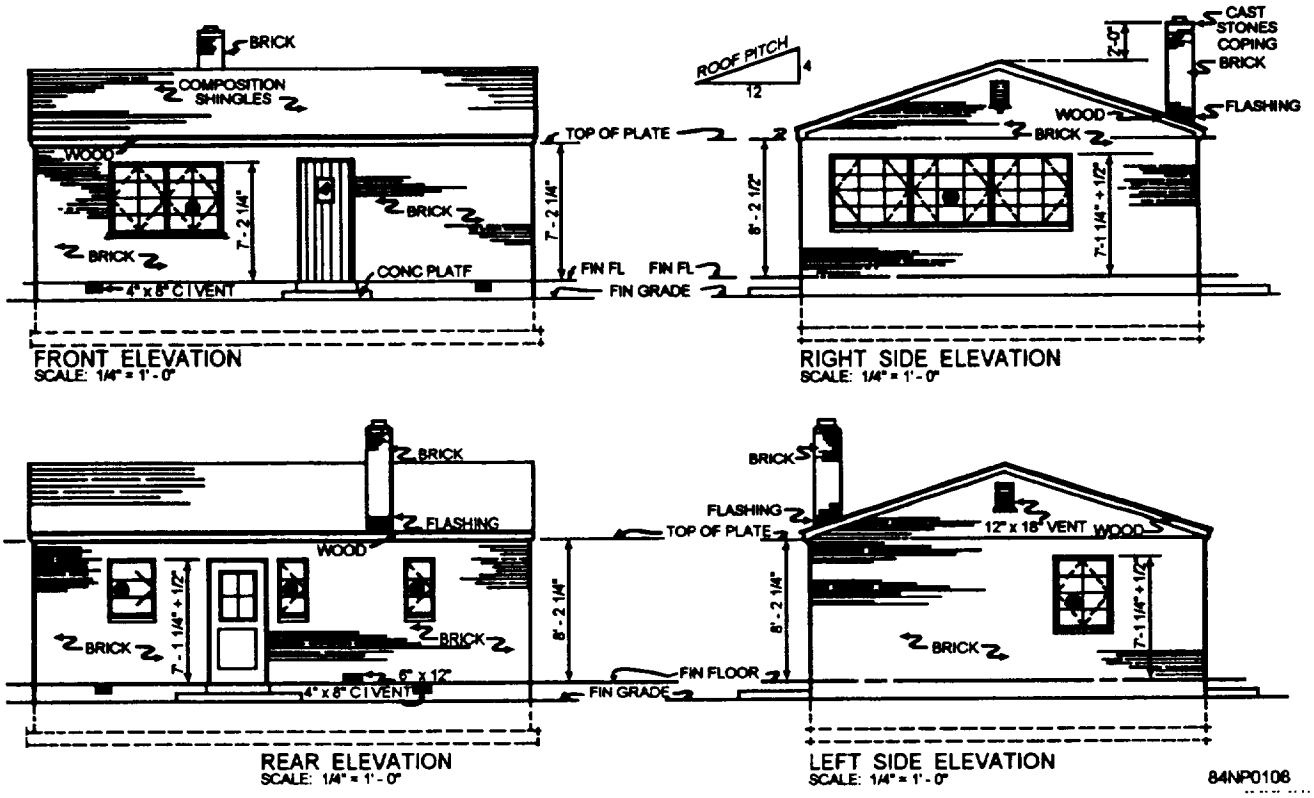


Figure 2-12.—Elevations.

Builders when they build the forms. The conduit will be placed in or through the form before the concrete is poured.

Mechanical Drawings

Mechanical drawings include all drawings and notes that have something to do with the water supply, sewage, drainage, heating and ventilating, refrigeration, air conditioning, and gas supply systems. It may also include other drawings that are necessary to present the system properly in relation to the other portions of the project.

Shop Drawings

Shop drawings are drawings and related data used to show some portion of the work prepared by the construction contractor, manufacturer, distributor, or supplier. Product data, such as brochures, illustrations, standard schedules, performance charts, and other information, are furnished by the contractor or the manufacturer to show a material, product, or system for some portion of the work. Engineering Aids are sometimes required to draft shop drawings for minor shop and field projects. These drawings may include shop items, such as doors, cabinets, and small portable buildings (prefabricated berthing quarters and modifications of existing structures), or they may come from portions of design drawings, specifications, or freehand sketches given by the design engineer. Working from a shop drawing is much like working from other working drawings. You convert the ideas you get from your interpretation of the lines and symbols into the product represented by the drawing.

ELECTRICAL DIAGRAMS

In addition to the construction drawings discussed above, you will be working with other types of electrical drawings or diagrams. These drawings show the arrangement and relationship of parts. Electrical diagrams are usually used to show how the parts of one or more pieces of equipment are wired together. There are several types of these diagrams. They are similar, yet different in some way. The short description of each that follows should enable you to recognize their differences.

Isometric Diagram

The isometric diagram is not often seen in electrical work. It may be used to show the electrical wiring system in multilevel buildings. Appliances sometimes have an isometric diagram glued to an access panel so that it may be referred to for a quick look at an entire wiring system. (See fig. 2-13.)

Block Diagram

A block diagram is a simple drawing showing the relationships of major parts of a wiring circuit or system. Figure 2-14 shows a block diagram of a motor control system You can easily see how it gets its name. Sometimes the blocks are connected with only one line that may represent one or more conductors or cables. Either major or minor components or parts may be represented by blocks. This type of diagram is often used to show something of the relationship of components in a power distribution system. The block diagram provides little help in troubleshooting.

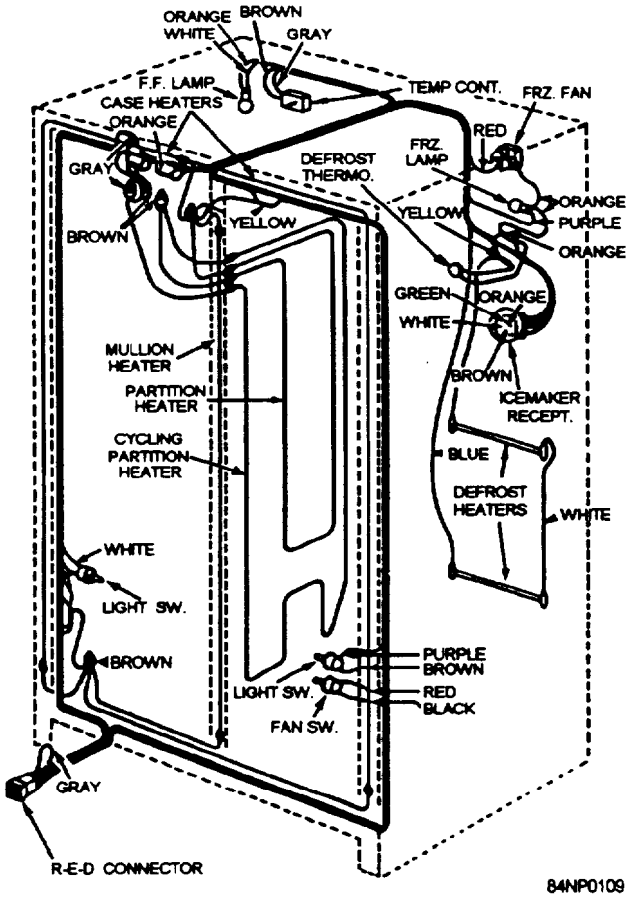


Figure 2-13.—Isometric wiring diagram.

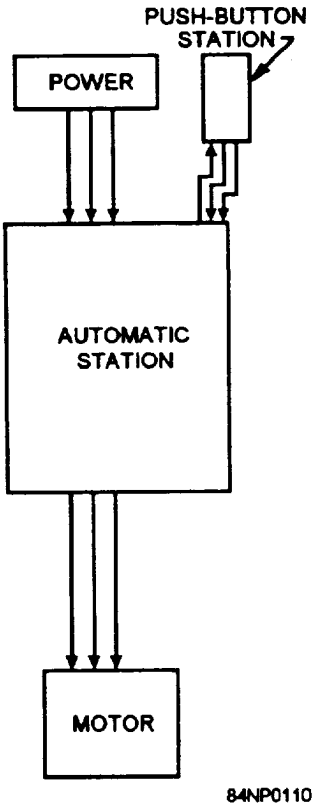


Figure 2-14.—Block diagram.

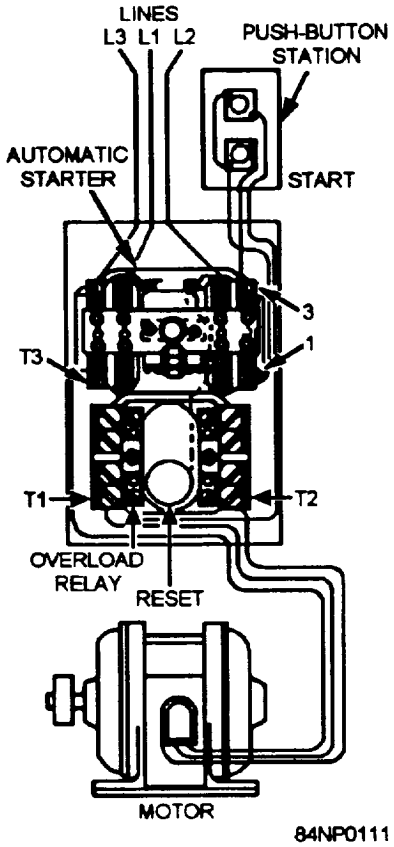


Figure 2-15.—Wiring diagram.

Wiring Diagram

The wiring diagram is almost a picture drawing. It shows the wiring between components and the relative position of the components. Figure 2-15 shows a wiring diagram of the same motor control system represented by the block diagram in figure 2-14. In the wiring diagram, components are shown much as they would appear in a picture. The lines representing wires are marked with numbers or letter-number combinations. Lines L1, L2, and L3 are incoming power leads. The diagram shows which terminals these power leads are connected to in the motor starter. Leads connected to terminals T1, T2, and T3 are the motor leads.

The numbers without letters mark the control terminals of the starter. Wiring diagrams are often used along with a list of repair parts. Wiring diagrams may be of some help in troubleshooting circuit problems.

Connection Diagram

Figure 2-16 is a connection diagram. By comparing the symbols from this diagram to those in figure 2-6, you can see that graphic symbols are used to represent parts or components in the connection diagram. The connection diagram in figure 2-16 is a combination of basic symbols (like the open-contact symbol). You can see how the controller pictured in figure 2-15 works internally.

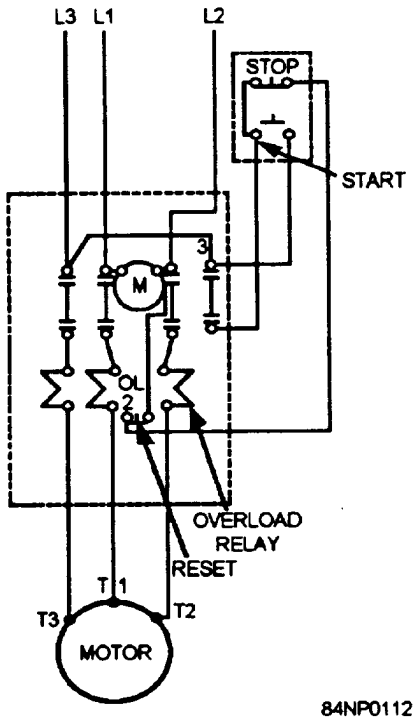


Figure 2-16.—Connection diagram.

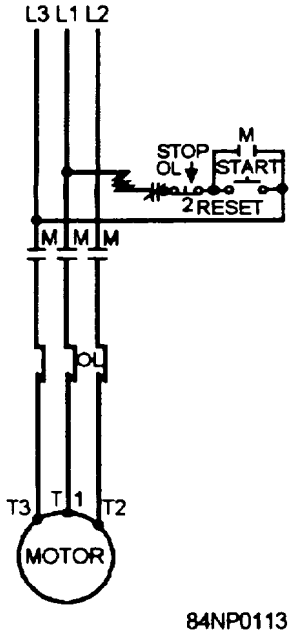


Figure 2-17.—Schematic diagram.

The connection diagram shows all the internal and external connections. The circuitry can be traced more easily than on the wiring diagram. The components are still shown in their relative positions. This diagram can be used to help you connect all the wiring and trace any part of the circuit. The connection diagram is a valuable troubleshooting tool. This type of diagram is often found inside the access cover of a piece of equipment.

Schematic Diagram

The schematic or elementary diagram (fig. 2-17) is a drawing that shows the electrical connections and functions of a specific circuit arrangement. It facilitates tracing the circuit and its functions without regard to the physical size, shape, or relative position of the component device or parts. The schematic diagram, like the connection diagram, makes use of symbols instead of pictures. Figure 2-17 shows, by a schematic diagram, the same motor control system shown in figures 2-14, 2-15, and 2-16. This diagram is laid out in a way that makes the operation of the components easy to understand. This type of schematic diagram with the components laid out in a line is sometimes called a one-line or single-line diagram.

Most schematic diagrams are more complicated than ‘the one shown in figure 2-17. The more complicated ones can be broken down into one-line diagrams, circuit by circuit. You can draw (or freehand sketch) your own one-line diagram by tracing only one circuit, component by component, through a multicircuit schematic, using the symbols in figure 2-6. Circuits "A" and "B" in figure 2-18 show only the control circuit from figure 2-16 laid out in one-line form. From these simple circuits, it is easy to see that as soon as the start button is pushed, the “M” coil (operating coil of the motor controller) will be energized. The operating coil is now held closed through the "M" contacts.

Your own freehand sketches can help you understand other types of diagrams as well as the schematic. You may vary these sketches to suit your needs. You may draw a one-line diagram, using symbols, from a wiring diagram, an isometric diagram, or a connection diagram, as long as all the necessary details are there for you to convert to lines and symbols.

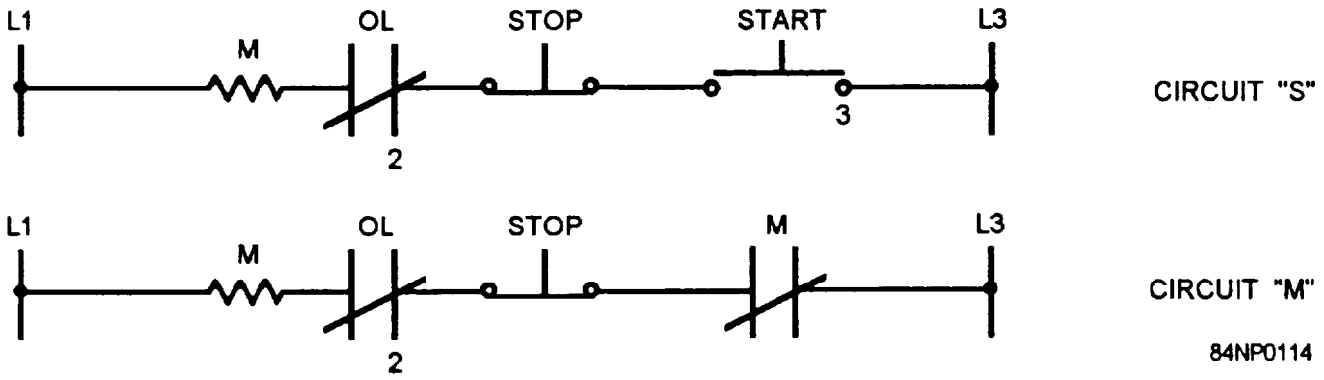


Figure 2-18.—One-line diagram of a motor control circuit.